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RANDOLPH AIR FORCE BASE, TEXAS

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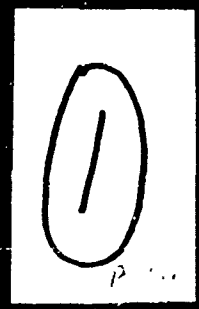

SOME EFFECTS OF NUCLEAR RADIATION EXPOSURE ON PRELIMINARY WGTA TRAINING PERFORMANCE OF RHESUS MONKEYS

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A number of investigators (3, 4, 6, 7, 8, 12, 13) have studied the effects of whole-body ionizing radiation on retention by monkeys for object discrimination tasks on the Wisconsin General Test Apparatus (WGTA). A few studies (1, 2, 4, 5, 9, 10, 11) have been concerned with the learning of new object discrimination tasks at some specified time after exposure of the subjects. In all of these studies the subjects had been trained to associate object blocks with food reward *before* the introduction of the radiation variable.

The present investigation, by way of contrast, studies the effects of previous exposure to whole-body irradiation on progression by monkeys through a series of training stages designed to prepare the subject for object discrimination testing on the WGTA. The investigation, in addition, studies the same animals with respect to simple object-quality discrimination learning unconfounded by previous training of a similar nature.

METHOD

Subjects

Sixty-four rhesus (*Macaca mulatta*) monkeys, ranging in age from 22 to 28 months, were employed as subjects. The control group consisted of 8 animals. The 56 animals of the experimental group were divided into eight subgroups, the animals of the subgroups having been placed at varying distances from ground zero for exposure to a nuclear radiation at the Nevada Test Site. The exposure predated the present study by approximately 11 months. The radiation dosages for the animals of each subgroup are shown in table I. For the purposes of the present study the animals of the control group and radiation subgroups I and J are designated as group 1, the animals of radiation subgroups F, G, and H as group 2, and the animals of radiation subgroups C, D, and E as group 3.[1] None of the animals had experienced previous training in the WGTA.

Procedure

A testing program was designed to train the animals (a) to take food from the test tray of the WGTA, (b) to associate object blocks with food, (c) to respond to object blocks only as such response is instrumental in procuring food, (d) to continue response to object blocks in spite of the distraction of the sliding screens of the WGTA, and (e) to continue response when only 50 percent of responses to object blocks are rewarded with food. This program involved five successive criteria which were tested in order as follows:

1. *Criterion 0.* If an animal, on the initial day of testing, failed to respond immediately to three pieces of food placed on the front-center surface of the test tray, he was tested to the criterion of 24 successive procurements of food from the surface of the test tray per day for two successive days before being tested on criterion I. If an animal, on the initial day of testing, responded immediately to food on the open test tray, his testing on criterion I was begun. Both screens of the WGTA remained up during all testing on criterion 0.

2. *Criterion I.* A red-painted square wooden block, measuring 3½ x 3½ x 1½ inches, was used in this as well as in all subsequent testing. The block was chained to the test tray by a length of plumber's chain to prevent the animal from pulling it to him in the test cage. The animal, on each trial, saw a piece

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[1] Subgroups were combined in order to meet the requirements of the chi-square test with respect to expected frequencies in each cell.

of food placed in the center food well of a tray having three food wells, saw the chained block placed over the baited food well, and was, then, given opportunity to push away the block and procure the food reward. Each animal, under this condition, was tested to the criterion of 24 successive manual responses to the chained block, which resulted in procurement of food reward, per day for 2 successive days.

3. *Criterion II.* Testing on criterion II was the same as on criterion I except that the forward screen was dropped during the baiting procedure. Twenty-four successive responses per day for 2 successive days were again required.

TABLE I

Dose levels for the animals of each subgroup

Subgroup	Gamma (r)	Neutron (rep)	Estimated total dosage (rem)
C	252	209	670
D	242	183	608
E	204	154	512
F	187	126	439
G	169	114	397
H	151	102	355
I	129	85	299
J	119	77	273

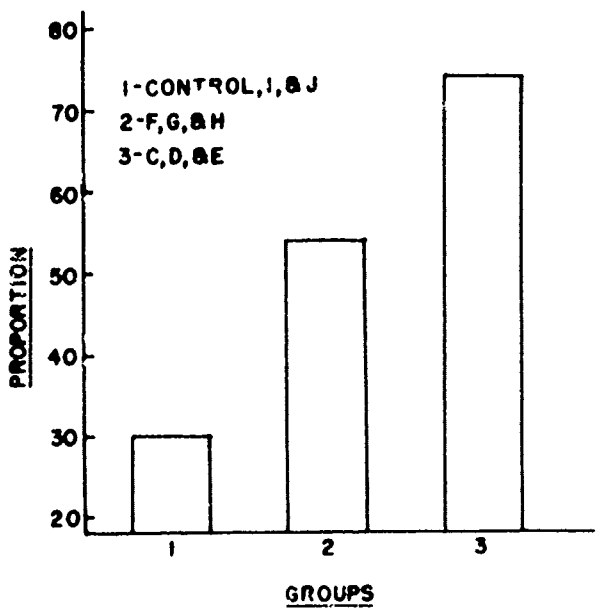

FIGURE 1

Proportion of subjects in each group responding immediately to food on the surface of the test tray on the initial day of testing.

4. *Criterion III.* Testing on criterion III was the same as on criterion II with the exception that the block was no longer chained to the test tray.

5. *Criterion IV.* Testing on criterion IV was the same as on criterion III with the exception that manual response to the block was randomly reinforced with food only 50 percent of the time.

If an animal failed to respond within 3 minutes in the appropriate manner at any stage of the day's training on each criterion, his testing was terminated for the day. Pieces of diced apple were used as the food reward.

After the training procedure, described above, was completed for all animals, testing was initiated on a single two-object discrimination problem. The positive of the two objects was a yellow-painted square wooden block, measuring 3 x 3 x ¾ inches, with a circular red-painted wooden block, measuring 2 inches in diameter and ¾ inches in depth, superimposed. The negative stimulus object was a yellow-painted square wooden block with the same dimensions as the base of the positive stimulus object. Each animal was tested 24 trials per day on this discrimination problem to a criterion of two successive days with 3 or fewer errors per day.

RESULTS

Figure 1 shows the proportion of animals in each group that responded immediately to food on the surface of the test tray on the initial day of testing. Statistical treatment of these data yielded a chi-square value of 16.4442 which, for 2 degrees of freedom, is significant beyond 0.1 percent confidence level. The probability of immediate response to food on initial exposure to the test situation increases directly with relative radiation dosage.

Figure 2 shows the median number of days to criterion for each group on each of the last four criteria. Only with respect to criterion I was a difference manifested. Statistical analysis of the data for criterion I, using the median test, yielded a chi-square value of 6.0770 which, for 2 degrees of freedom, is significant beyond the 5.0 percent confidence level. The median days to criterion was significantly greater for the animals of group 3 than for the animals of either group 1 or 2, suggesting slower association of the object block with food reward for the animals

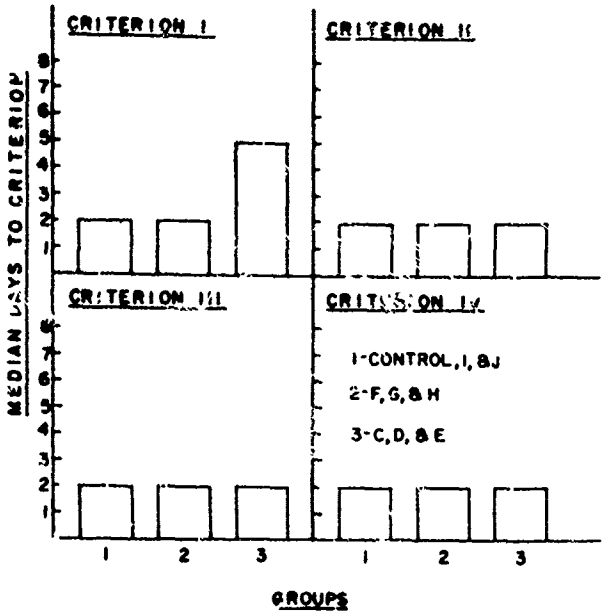

FIGURE 2

Median number of days to criterion for each of the 3 groups on each of criteria I through IV.

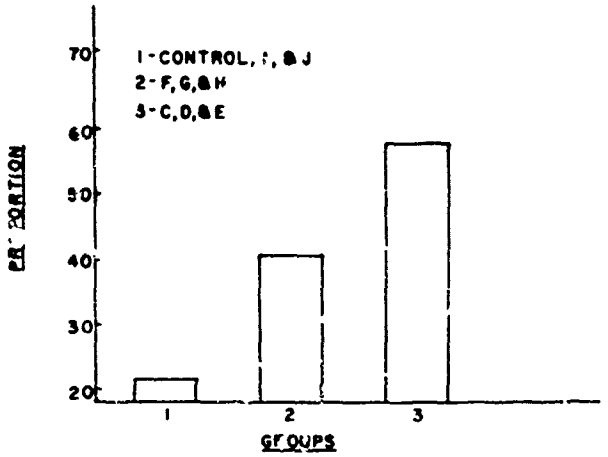

FIGURE 3

Proportion of subjects in each group at or below the common median number of days to criterion on the simple discrimination problem.

of group 3 than for the animals of the other two groups.

Figure 3 compares the groups with respect to proportion of subjects in each group at or below the common median number of days to criterion on the simple discrimination problem. Statistical analysis of these data, comparing proportions above the common median to proportions at or below the common median, yielded a chi-square value of 7.9869 which, for 2 degrees of freedom is significant beyond the 2.0 percent confidence level.

DISCUSSION

The data of this study show that the higher the dose of previous whole-body irradiation (within the range of the dosages used) the greater the probability of immediate response to food by monkeys when first placed in the WGTA, the slower the association between an object block and food, and, once such an association has been formed, the faster the discrimination between a food-rewarded and a nonfood-rewarded object block. These findings, based on an independent group of animals subjected to field rather than laboratory administered radiation, provide confirmation of a hypothesis previously advanced by McDowell and Brown (10).

These investigators hypothesized, in order to explain facilitative effects of irradiation on performance of monkeys on discrimination problems with reduced stimulus cues, that previous irradiation elevates the thresholds of all the responses to the stimuli in the animal's environs to the same degree with the consequence that the response-provoking potentialities of the weaker stimuli are reduced or lost and an increased percentage of total responses are directed to the stronger stimuli. In the present study, in line with this hypothesis, the higher the previous dosage the faster the response to food (which is a relatively strong stimulus), the slower the response to a wooden object block (which is a relatively weak stimulus), and the faster the discrimination of a food-rewarded object block after object blocks had acquired the stimulus value of food.

SUMMARY

Sixty-four naive rhesus monkeys, divided into three radiation subgroups, were studied with respect to progression through a series of training stages designed to prepare the subjects for object discrimination testing on the WGTA. The subgroups were also compared on simple

object-quality discrimination learning. The exposure to a nuclear radiation predated the present study by approximately 11 months. The results were as follows:

1. The higher the previous radiation dosage, the faster the response to food when initially placed in the WGTA.

2. The higher the previous radiation dosage, the slower the response to a wooden object block as a sign for food.

3. The higher the previous radiation dosage, the faster the discrimination of a food-rewarded object block after object blocks had acquired the stimulus value of food.

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